



ENERGY TECHNOLOGIES

Think of BMDO technology transfer the next time you

- Drink water or soda at a restaurant.
- Visit a solar-powered home.
- Turn on your car's air conditioner on a hot day.
- Turn on a light switch or pay your power bill.



ZAPPED! CAPACITORS CHARGE AGAINST MICROBES

High-energy capacitors zap pathogenic microbes to purify water, sterilize pharmaceutical products, and reduce bacteria levels on foods.



■ A large international food chain will use PurePulse's PureBright® system (pictured above) to decontaminate water.

You may not recognize its tongue-twisting scientific name. But you might remember *Cryptosporidium* was the “bug” that made Milwaukee famous.

In this city during the summer of 1993, a major outbreak of the waterborne parasite occurred, sickening more than 400 people. By the time the outbreak ended, 100 people had died. It was the largest episode of waterborne disease in the United States in the 70 years since health officials began tracking such outbreaks.

PurePulse Technologies, Inc., a subsidiary of Maxwell Technologies, Inc. (San Diego, CA), has developed a fast and efficient method for eliminating deadly bacteria, viruses, and other microorganisms, including *Cryptosporidium*. Dubbed PureBright®, this system uses concentrated energy in short, high-intensity pulses to rupture the membranes of pathogenic microbes without using heat, chemicals, or ionizing radiation. Based on advanced high-energy capacitors, the system offers kill rates 100 to 10,000 times those of conventional mercury lamp ultraviolet treatments.

A little zap will do. Capacitors, the key to PureBright technology, accumulate electrical charge and energy on the surfaces of conducting plates that are insulated from each other by a dielectric material. Maxwell developed its capacitors by using insulating materials with a higher dielectric constant, reducing the thickness of the material, increasing the voltage between conductors, and reducing the thickness of the conducting plates. BMDO partially funded development of these capacitors to produce a compact, lightweight device that could provide pulsed power for space-based lasers and accelerators.

PureBright is highly effective in killing microorganisms such as vegetative bacteria, yeasts, molds, bacteria spores, and viruses. “The light does not penetrate opaque materials, but is transmitted through many types of clear packaging materials, fluids, and air,” says Kent Salisbury, Maxwell’s PurePulse program manager. “PureBright’s extremely short exposure time greatly reduces the potential for material degradation. The treatment is a clean process, leaving no chemical residues and requiring no evacuation steps.”

PurePulse is aggressively capitalizing on its unique PureBright technology in the commercial marketplace by forming alliances and establishing licenses. For

example, the company has teamed with Tetra Pak and Automatic Liquid Packaging to commercialize the PureBright process for food and pharmaceutical packaging applications, respectively. In another example, PurePulse and a major manufacturer and marketer in the health care field agreed to pursue a licensing and purchase agreement to use PureBright technology for sterilizing certain disposable consumer products. This agreement involves technology rights and the purchase of several PureBright systems, with a value over \$2 million over the next several years.

The company recently found a new market for PureBright technology—water purification. Thanks to a \$1 million grant from a large international food chain, PurePulse has developed a system that can clean 4 gallons of water a minute and easily fit into commercial kitchens. The system will allow restaurants to serve their customers safer water, hot and cold beverages, and ice cubes. With field testing nearly complete, the water purifier will soon be available on the market.

Ultrapure water. PurePulse is also making significant inroads in industry. In early 1998, the company signed an agreement with Pall Corporation that could lead to the commercialization of its PureBright technology for producing high-purity water for the semiconductor industry. According to PurePulse, the market for ultrapure water for semiconductor manufacturing and other industrial scientific applications is estimated to be over \$200 million.

High-energy density capacitors similar to those used in PureBright systems also have been incorporated into heart defibrillators that deliver an electrical current (a shock) to a heart in cardiac arrest. The defibrillator interrupts the heart's chaotic heart rhythm, known as ventricular fibrillation, allowing it to stop very briefly and begin beating again rhythmically; the sooner the heart can be defibrillated following cardiac arrest, the greater the patient's chance of survival. Maxwell has developed four types of external heart defibrillators and annually sells about 20,000 of them to 10 original equipment manufacturers.

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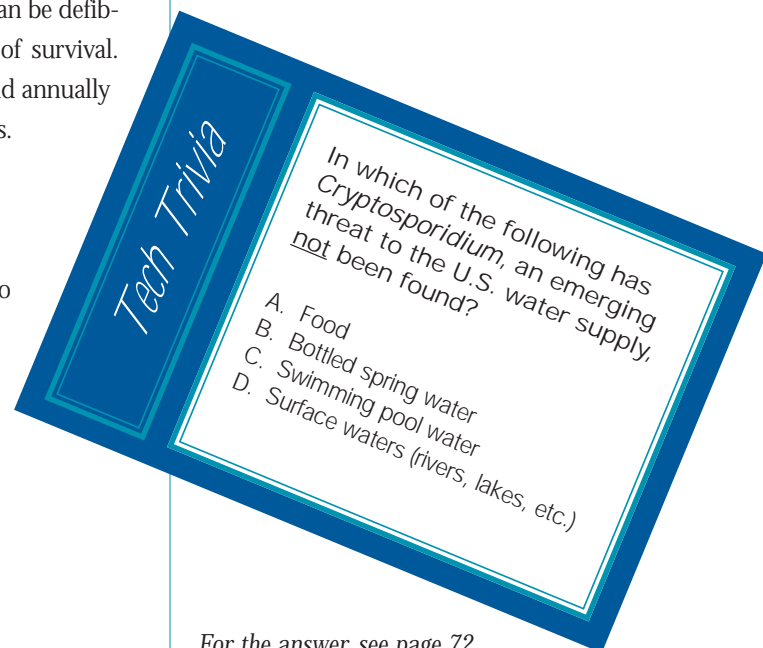
What Does It Mean to You?

Short, intense pulses of light can help eliminate deadly bacteria, viruses, and other microorganisms, allowing restaurants to serve safer drinking water, hot and cold beverages, and ice cubes.



What Does It Mean to Our Nation?

Pulsed-power technologies are being used more often to purify water, helping stave off widespread outbreaks of *Cryptosporidium* and other deadly microorganisms.



For the answer, see page 72.

TAPPING THE SUN IN THE NEXT MILLENNIUM

An optical lens device concentrates sunlight onto solar cells, providing cost savings for photovoltaic systems powering spacecraft and homes.



■ SCARLET™ technology (pictured above) concentrates light to the strength of many suns onto a small area of solar cells.

How expensive is it to use solar electricity to power next-generation communications satellites? Even though sunlight is inexhaustible and free, a conventional satellite solar cell array that generates 15 kilowatts (kW)—enough power to heat a small house—can cost as much as \$20 million to build. Furthermore, because of their bulky, rigid designs, these arrays can significantly increase a satellite's launch costs.

ENTECH, Inc. (Keller, TX), has developed an optical lens device, called the line-focus Fresnel lens, that could save millions of dollars in deployment costs for solar-powered spacecraft. The lens reduces the amount of solar cell material needed to produce a given amount of power by a factor of 10. Because considerably less cell area than is required with conventional arrays, tremendous weight and cost savings can be realized. In addition, because of its light concentration effects and ability to use cell material optimized for the focused wavelengths, the lens greatly enhances power efficiencies.

Magnifying glass. Like a magnifying glass, the lens captures, funnels, and concentrates sunlight. Its cylindrical design has a smooth outer surface and an inner surface made of microscopic prisms that shape the light with a much higher efficiency than previous solar concentrator designs. BMDO, which initially funded ENTECH's design concept through an SBIR contract, is funding further research and development on the lens for the Solar Concentrator Array with Refractive Linear Element Technology (SCARLET™) program.

ENTECH and AEC-Able Engineering Company, Inc. (Goleta, CA), have developed two lens designs, SCARLET I and II, for future advanced space power applications. Although the METEOR I launch vehicle carrying SCARLET I failed 45 seconds after its October 1995 launch, another SCARLET array, which has been further enhanced, was chosen for NASA's New Millennium Deep Space 1 (DS1) spacecraft, which was launched in October 1998.

Two SCARLET II solar wing assemblies consisting of 720 ENTECH line-focus Fresnel lenses will power the DS1 spacecraft and its revolutionary ion thrusters. This mission will mark the first time that ion propulsion, rather than chemical-based propulsion, is being used as a primary means to propel a spacecraft. Once proven to work, solar-powered ion thrusters will enable next-generation spacecraft to travel 10 times faster than those using chemical propellant systems.

Buying more sun for the dollar. SCARLET II solar arrays can provide spacecraft makers with a tremendous cost savings. "In a recent study, AEC-Able found that SCARLET II technology could save an estimated \$9 million to \$13 million when it is used to replace a conventional 15 kW gallium arsenide on germanium array," says Mark O'Neill, ENTECH's president. "That's a savings of \$600 to \$900 per watt of array power, which enables companies to buy a lot more sun for their dollar." ENTECH has an exclusive agreement with AEC-Able for the space-based concentrator. The team hopes to capture a large portion of the communications satellite market, and by using SCARLET II technology, hopes to significantly reduce solar array costs. A more compact third-generation SCARLET array is currently being developed.

In addition, ENTECH is pursuing terrestrial applications for its solar concentrator. For example, its SolarRow product is designed to provide renewable electrical power with zero emissions for utility-scale applications. In late 1996, ENTECH was selected by a team led by Nevada Power Corporation to provide large-scale solar power plants for the Solar Enterprise Zone (SEZ) in Nevada. The SEZ project could result in 20-megawatt capacity of ENTECH equipment installed and operating in the Nevada desert within the next five years. In the Southwest, two electric utilities have recently built 100 kW power plants using ENTECH SolarRows.

The company's SUNLINE™ stand-alone power units can supply power for small or remote electricity demands. These units can offer a clean, quiet, non-polluting, renewable power source for a wide range of applications, including lights, water pumps, small villages, remotely located homes, and water purification systems.

■ For more information, contact Mark O'Neill via telephone at (817) 379-0100 or via E-mail at moneill@startext.net. You can also visit ENTECH's Web site at <http://www.entsolar.com>.



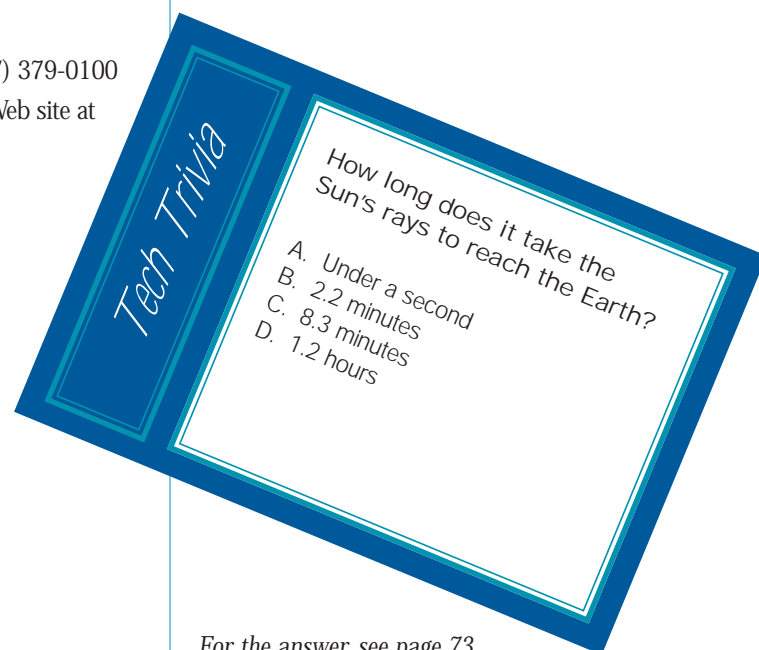
What Does It Mean to You?

Fresnel lenses increase solar cell efficiency and reduce array costs, bringing solar electricity one step closer to reality as a cheap, pollution-free power source for homes and businesses.



What Does It Mean to Our Nation?

By enabling cheaper, more powerful spacecraft, solar concentrators will help facilitate the launch of communications satellites and U.S. Government-sponsored exploratory spacecraft.



For the answer, see page 73.

LIQUID ADDITIVE IS COOL FOR AIR CONDITIONERS

A liquid additive for air conditioners, heat pumps, and refrigeration systems improves cooling performance by boosting capacity and efficiency.



■ QwikBoost™ (pictured above) is expected to increase the cooling capacity of automobile air conditioners by 10 percent and cool the passenger space of vehicles faster than existing technology.

On hot days, does your car feel more like an oven? Summer heat can raise temperatures to dangerous levels, especially inside a car. And many people do not realize how quickly a car's interior can heat up—even with the windows down several inches. For example, when the outside temperature is 83°F, the temperature inside your car can reach 109°F in just 15 minutes.

Unfortunately, there is little to keep you from roasting before the air conditioning kicks in. And, once it does, the supply of cool air never seems to be enough.

This summer, automotive air conditioners will be better prepared to beat the heat, thanks to a liquid performance additive developed by Mainstream Engineering Corporation (Rockledge, FL). Called QwikBoost™, the new additive is expected to boost cooling capacity by 10 percent. It will also cool the interior of vehicles faster than existing technology. Mainstream Engineering has packaged its additive and a small quantity of R-134a refrigerant in a single-dose 3-ounce can, soon to be available at local automotive supply outlets.

Easy work. When added to a vapor compression air conditioner, heat pump, or refrigeration system, the additive significantly improves the coefficient of performance (COP) of the system, thereby reducing its energy consumption. The COP is a measure of system efficiency as indicated by the ratio of cooling output to the input energy. QwikBoost circulates through the refrigeration system with the working fluid. It increases the available cooling capacity (latent heat) of the refrigerant during the evaporation process, thereby resulting in better performance.

Mainstream Engineering developed the initial technology under BMDO SBIR contracts for advanced heat pumps for spacecraft heat rejection systems. This effort evaluated four heat pump configurations for use as spacecraft heat rejection systems. One of these system evaluations, based on a chemical/mechanical heat pump, led to the development of the performance-enhancing additive. Subsequent development work was performed under NASA and Air Force SBIR contracts.

One concern about using liquid additives in air conditioning equipment has been whether these products adversely affect system lubrication or compressor life. "Lubrication tests, performed at an independent laboratory, and compressor life tests have indicated that QwikBoost does not adversely affect compres-

sors,” says Larry Grzyll, Mainstream Engineering’s senior chemical engineer. “In fact, test results show that a QwikBoost/lubricant mixture produces less wear than the pure polyol ester refrigeration lubricant typically used in today’s refrigeration systems.”

Another benefit of QwikBoost is that it enhances air conditioner performance without adversely affecting the environment. A few years ago, environmental regulations forced automobile manufacturers to replace systems using R-12 air conditioner coolant, which contains chlorofluorocarbons, with less-polluting systems using R-134a coolant—a move that left consumers underwhelmed with the lower performance of the new and retrofit systems. Mainstream is marketing QwikBoost as a solution to these performance problems. Of the 150 million air-conditioned cars on the road today, roughly 90 million still use R-12 coolant.

Award winner. Mainstream Engineering has a strong and ongoing commitment to commercializing QwikBoost. The U.S. Small Business Administration has recognized this commitment and honored the company with one of its annual Tibbetts Awards in 1997. The Tibbetts Awards recognize superior SBIR technological innovation, economic impact, and business achievements. Less than a year later, QwikBoost was first introduced at the International Air Conditioning, Heating, and Refrigeration Exposition in San Francisco, California.

Mainstream Engineering believes that the additive also could be used for industrial and commercial medium-temperature refrigeration, such as supermarket refrigerated cases. This market is very significant in that refrigeration represents more than half the energy consumed by the U.S. food sales sector. For example, the U.S. food sales sector in 1995 consumed about 71 trillion British thermal units (Btus) of energy for refrigeration out of its total consumption of 137 trillion Btus. According to these numbers, refrigeration accounted for roughly 52 percent of the total energy consumed by this sector.

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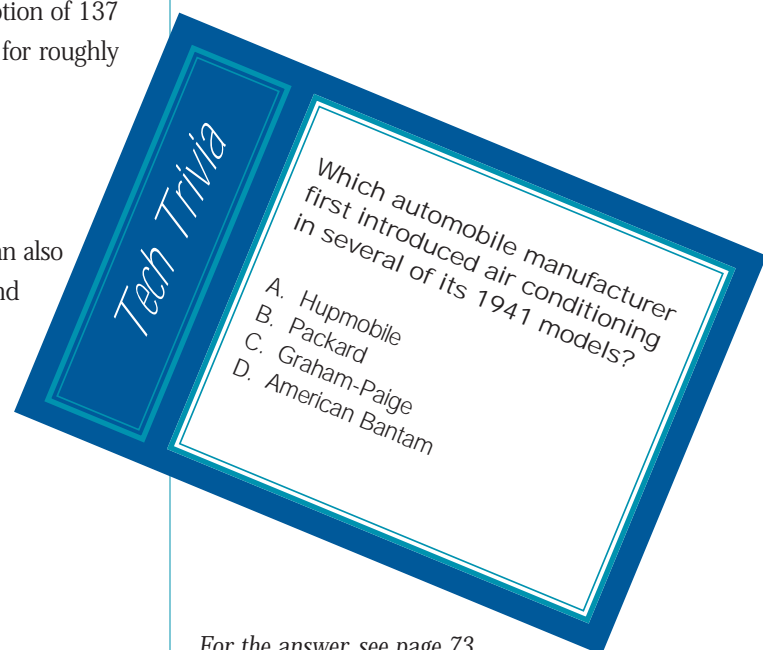
What Does It Mean to You?

QwikBoost will help automotive air conditioners cool the interior faster and produce more cool air, enabling occupants to beat the heat on hot summer days.



What Does It Mean to Our Nation?

QwikBoost can help boost the performance of the Nation’s industrial and commercial refrigeration equipment, which plays a critical role in preserving food and storing medical supplies.



For the answer, see page 73.

ULTRAFAST SWITCH ENERGIZES DIVERSE MARKETS

An ultrafast optical switching technology finds its way into sensor, medical, manufacturing, electrical utility, and scientific instrumentation markets.



■ The silicon switch (pictured above), developed by Energy Compression Research, can be used in medical, manufacturing, and electrical utility applications.

For more than 30 years, electronic switches have quietly toiled in the fields of electronics, electro-optics, and photonics. Now, optical switches are shaking up the peace.

With the introduction of more sophisticated devices, it generally has become more difficult to perform switching functions electronically. Optically, however, things get easier. Optical switches have faster response times than electronic switches and are less susceptible to electromagnetic interference, making them attractive for a wide range of commercial applications.

Energy Compression Research Corporation (ECR; San Diego, CA) has introduced an optical switching technology, called light-activated silicon switching (LASS), that offers an ultrafast alternative to electronic switches. With picosecond switching speeds and compact packaging, LASS switches have enabled a wide range of high-end commercial products for electronics, electro-optics, and photonics applications. The switches can be used to power lasers, route signals in fiber-optic communications devices, control industrial motors, and power high-frequency radar communications. LASS technology offers high efficiency and cost savings in these areas.

Light switching. LASS technology is based on semiconductor devices that use laser light to switch current on and off. A LASS device uses the absorption of laser light to create the conducting electrons within the semiconductor, resulting in a switching speed that is orders of magnitude faster than conventional electronic switches. ECR developed LASS photoconductive switches with support from Phase I and II BMDO SBIR contracts. These switches were originally designed for BMDO applications in pulsed radar, pulsed power for accelerators, and electromagnetic weaponry.

After the U.S. Department of Defense declassified LASS patents, ECR immediately began an aggressive plan to develop and commercialize LASS technology. On the basis of a market study to identify specific customer needs, which revealed an emerging market for ultrafast optical switches, the company developed LASS-based products and established a manufacturing capability. ECR introduced its first products, the ECR Pockels cell drivers, in January 1995 and completed over \$274,000 in product sales during the year. LASS-based technology is now nearing the million dollar mark in total product sales.

With the maturation of LASS, the company has transitioned its business focus from defense to commercial markets. "During our strategic work for the defense industry, we developed a large body of proprietary knowledge on how to 'marry' semiconductors and photoconductive switches to achieve previously unachievable performance in terms of speed and power," says Andrew Palowich, ECR's chief executive officer and president. "Knowing how to manufacture and integrate photoconductors with numerous associated electro-optic devices has enabled us to find much broader commercial markets."

Versatile tools. LASS's high-speed switching capabilities can boost the performance of a wide variety of products and applications, including robotic vision systems that enhance quality control in manufacturing. In addition, LASS-based light detection and ranging equipment can be used for high-accuracy proximity measurements based on reflectance. For instance, this reflectance method is used to measure the distance from the earth to communications and global positioning satellites. For biotechnology tasks, compact microlasers can be incorporated into fluorescence lifetime sensors and flow cytometers, saving space and improving instrument accuracy.

Medical applications abound for ECR's technology. LASS can be incorporated into high-repetition-rate medical lasers, such as those used in refractive eye surgery. It helps provide ultrashort pulse times with low jitter and high accuracy to reduce collateral damage to the eye. LASS also could be used in optical diffuse tomography (ODT), which uses non-ionizing laser light to create anatomical images. Although ODT is still in its infancy, researchers hope it can become a supplement to mammography, much in the way ultrasound fills that role today.

The electrical power industry is keeping its eye on LASS technology, too. In a recent study funded by the Electric Power Research Institute, ECR demonstrated in fault applications the ability to shunt a surge of 10,000 amps in 2 microseconds—five times faster than the thyristors used for this purpose. Currently, ECR is designing LASS surge-suppressing thyristors for high-power electric utility grids. Commercial devices should be available in 1999.

ECR is busy expanding its product line and currently offers Q-switched picosecond microlasers, solid-state laser-diode drivers, and fast Pockels cells. The company sells products and provides research and development services directly throughout the United States, and through eight distributors internationally. Major customers include AT&T, Toshiba, and Boeing.

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What Does It Mean to You?

Light-activated switches are versatile tools that can be used to increase the accuracy of lasers for eye surgery and boost the performance of industrial vision systems for quality control.



What Does It Mean to Our Nation?

LASS technologies can benefit utilities by helping to ensure reliable power grids to light up U.S. homes and businesses.

Tech Trivia

The human brain packs enough power (electricity) to do which of the following?

- A. Give a mild shock to your finger
- B. Heat an 8-ounce cup of coffee
- C. Light a 15-watt light bulb
- D. Short-circuit your hard drive

For the answer, see page 73.